PROJECT facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

High Efficiency Engines and Turbines

12/2002

ATTENUATION OF HOT STREAKS AND INTERACTION OF HOT STREAKS WITH THE NOZZLE GUIDE VANE AND ENDWALL

PRIMARY PARTNER

University of Texas at Austin

TOTAL ESTIMATED COST

$ 324,900

CUSTOMER SERVICE

800-553-7681

STRATEGIC CENTER FOR NATURAL GAS WEBSITE

www.netl.doe.gov/scng

Description

Under the Advanced Gas Turbine Systems Research (AGTSR) program, the University of Texas (UT), is evaluating the effects of non-uniform combustor patterns (hot streaks) on end walls and first stage vanes with Virginia Tech (VT) under subcontract and interacting with General Electric, Pratt&Whitney, and Rolls-Royce. Task 1 involves discussions with the turbine company participants to define hot streak profiles, boundary layers, and film-cooling hole patterns to be represented in experiments and computer simulations. Task 2 conducts common benchmark tests at UT and VT in which a hot streak is positioned at the mid-span of an uncooled vane leading edge. Comparison of the thermal fields by both groups will be made to verify that the hot streak characteristics and interactions with the vane are reproducible between the separate laboratories. Tasks 3-7 conduct experiments and computer simulations at VT representing uncooled and film-cooled end walls, using various hot streak temperature patterns and low and high turbulence levels, to evaluate the effects of end wall cooling on the distortion and attenuation of hot streaks. Figure 1 shows the VT test facility. Tasks 8-10 conduct experiments at UT representing uncooled and cooled vanes, using various hot streak temperature patterns, turbulence levels, and cooling configurations, to evaluate the effects of vane cooling on the distortion and attenuation of hot streaks. Experiments in Task 11 at UT evaluate the effects

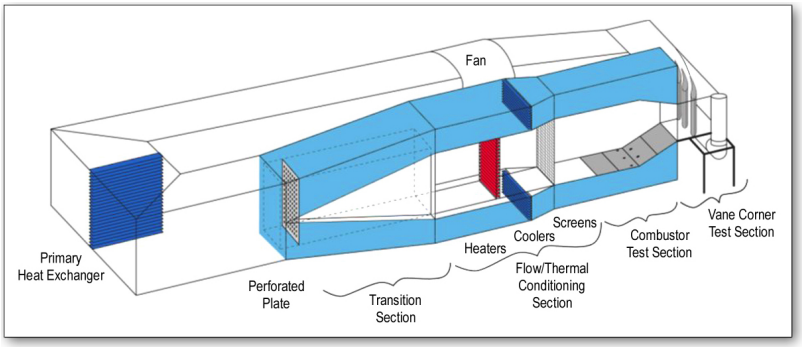

Figure 1. Overview of VTExCCL Wind Tunnel Facility showing complete loop

Attenuation of Hot Streaks and Interaction of Hot Streaks with the Nozzle Guide Vane and Endwall

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Description (continued)

of surface roughness, representative of turbine deposition and erosion, on the approach flow to cooling holes. If these surface roughness effects are found important, Task 12 at UT represents deposition/erosion roughness in experiments to determine the effects of hot streaks on vane film cooling performance. If surface roughness effects are not found important, Task 12 experimentally evaluates the use of coolant injection to disperse and favorably attenuate hot streaks. Interactions in Task 13 analyze the data and disseminate the database to the participating turbine companies in the project.

Duration

24 months

Goals

This project investigates how the hot streaks from turbine combustors increase the heat load to first stage nozzle vanes and their end walls and how hot streaks are attenuated by film-cooling of turbine surfaces.

Benefits

The maximum temperatures in a gas turbine are associated with hot streaks from the combustor. Consequently, the most stringent requirements for cooling and materials selection of the downstream airfoils and end walls result from these hot streaks. The hot streaks affect film cooling of the first stage vanes and end walls. That cooling modifies the temperature patterns leaving the first stage vanes and resulting thermal loads and cooling/materials design requirements for downstream surfaces. This project provides a database to turbine engineers of interactions of hot streaks and vane/endwall heat transfer for cooling design and materials selection.